



# THE DATASHEET OF SN65HVD20DR



## SN65HVD2x Extended Common-Mode RS-485 Transceivers

### 1 Features

- Common-Mode Voltage Range (–20 V to 25 V) More Than Doubles TIA/EIA-485 Requirement
- Receiver Equalization Extends Cable Length, Signaling Rate (SN65HVD2[3,4])
- Reduced Unit-Load for up to 256 Nodes
- Bus I/O Protection to Over 16-kV HBM
- Failsafe Receiver for Open-Circuit, Short-Circuit, and Idle-Bus Conditions
- Low Standby Supply Current 1  $\mu$ A (Maximum)
- More Than 100 mV Receiver Hysteresis

### 2 Applications

- Long Cable Solutions
  - Factory Automation
  - Security Networks
  - Building HVAC
- Severe Electrical Environments
  - Electrical Power Inverters
  - Industrial Drives
  - Avionics

### 3 Description

The transceivers in the SN65HVD2x family offer performance far exceeding typical RS-485 devices. In addition to meeting all requirements of the TIA/EIA-485-A standard. The SN65HVD2x family operates over an extended range of common-mode voltages and has features such as high ESD protection, wide receiver hysteresis, and failsafe operation. This family of devices is ideally suited for long-cable networks and other applications where the environment is too harsh for ordinary transceivers.

These devices are designed for bidirectional data transmission on multipoint twisted-pair cables. Example applications are digital motor controllers, remote sensors and terminals, industrial process control, security stations, and environmental control systems.

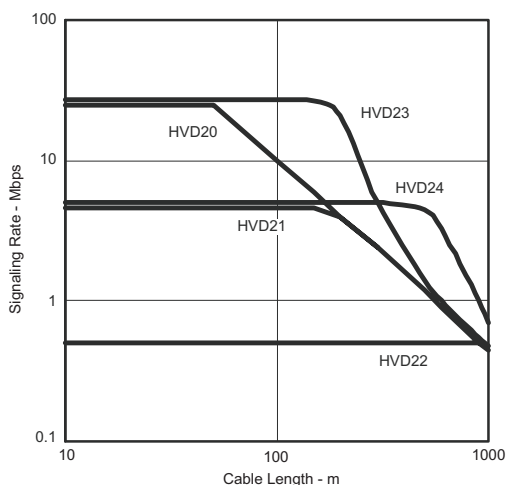
These devices combine a 3-state differential driver and a differential receiver that operate from a single 5-V power supply. The driver differential outputs and the receiver differential inputs are connected internally to form a differential bus port that offers minimum loading to the bus. This port features an extended common-mode voltage range, making the device suitable for multipoint applications over long cable runs.

#### Device Information<sup>(1)</sup>

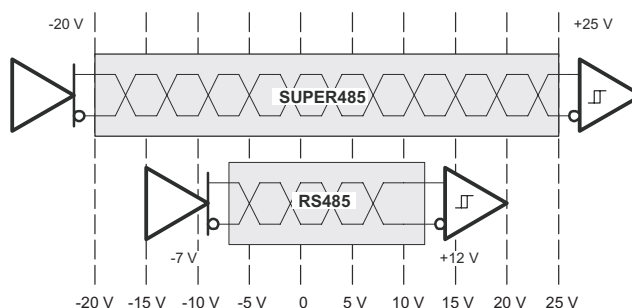
| PART NUMBER | PACKAGE  | BODY SIZE (NOM)   |
|-------------|----------|-------------------|
| SN65HVD2x   | SOIC (8) | 4.90 mm × 3.91 mm |
|             | PDIP (8) | 9.81 mm × 6.35 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

#### SN65HVD2x Application Space



#### SN65HVD2x Devices Operate Over a Wider Common-Mode Voltage Range



## Table of Contents

|                                                  |           |                                                                  |           |
|--------------------------------------------------|-----------|------------------------------------------------------------------|-----------|
| <b>1 Features</b> .....                          | <b>1</b>  | <b>10 Detailed Description</b> .....                             | <b>17</b> |
| <b>2 Applications</b> .....                      | <b>1</b>  | 10.1 Overview .....                                              | 17        |
| <b>3 Description</b> .....                       | <b>1</b>  | 10.2 Functional Block Diagram .....                              | 17        |
| <b>4 Revision History</b> .....                  | <b>2</b>  | 10.3 Feature Description .....                                   | 17        |
| <b>5 Description (continued)</b> .....           | <b>4</b>  | 10.4 Device Functional Modes .....                               | 19        |
| <b>6 Device Options</b> .....                    | <b>4</b>  | <b>11 Application and Implementation</b> .....                   | <b>22</b> |
| <b>7 Pin Configuration and Functions</b> .....   | <b>5</b>  | 11.1 Application Information .....                               | 22        |
| <b>8 Specifications</b> .....                    | <b>5</b>  | 11.2 Typical Application .....                                   | 22        |
| 8.1 Absolute Maximum Ratings .....               | 5         | <b>12 Power Supply Recommendations</b> .....                     | <b>24</b> |
| 8.2 ESD Ratings .....                            | 6         | <b>13 Layout</b> .....                                           | <b>24</b> |
| 8.3 Recommended Operating Conditions .....       | 6         | 13.1 Layout Guidelines .....                                     | 24        |
| 8.4 Thermal Information .....                    | 7         | 13.2 Layout Example .....                                        | 25        |
| 8.5 Driver Electrical Characteristics .....      | 7         | <b>14 Device and Documentation Support</b> .....                 | <b>26</b> |
| 8.6 Receiver Electrical Characteristics .....    | 8         | 14.1 Related Links .....                                         | 26        |
| 8.7 Driver Switching Characteristics .....       | 8         | 14.2 Receiving Notification of Documentation Updates .....       | 26        |
| 8.8 Receiver Switching Characteristics .....     | 9         | 14.3 Community Resources .....                                   | 26        |
| 8.9 Receiver Equalization Characteristics .....  | 9         | 14.4 Trademarks .....                                            | 26        |
| 8.10 Power Dissipation .....                     | 10        | 14.5 Electrostatic Discharge Caution .....                       | 26        |
| 8.11 Typical Characteristics .....               | 11        | 14.6 Glossary .....                                              | 26        |
| <b>9 Parameter Measurement Information</b> ..... | <b>12</b> | <b>15 Mechanical, Packaging, and Orderable Information</b> ..... | <b>26</b> |

## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision E (May 2010) to Revision F                                                                                                                                                                                                                                            | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Added ESD Ratings table, Feature Description section, Device Functional Modes, Application and Implementation section, Power Supply Recommendations section, Layout section, Device and Documentation Support section, and Mechanical, Packaging, and Orderable Information section. .... | 1    |
| • Deleted Ordering Information table; see POA at the end of the data sheet. ....                                                                                                                                                                                                            | 1    |
| • Added maximum temperature value (150°C) to "Storage temperature, $T_{stg}$ parameter. ....                                                                                                                                                                                                | 5    |

| Changes from Revision D (April 2005) to Revision E                                                                | Page |
|-------------------------------------------------------------------------------------------------------------------|------|
| • Replaced the Dissipation Rating table with the THERMAL INFORMATION table. ....                                  | 7    |
| • Changed $I_O$ - Added test condition and values per device number (DRIVER ELECTRICAL CHARACTERISTICS table) ... | 7    |
| • Changed the THERMAL CHARACTERISTICS table to POWER DISSIPATION table .....                                      | 10   |
| • Added the TEST MODE DRIVER DISABLE section. ....                                                                | 20   |

| Changes from Revision C (September 2003) to Revision D                                                                                   | Page |
|------------------------------------------------------------------------------------------------------------------------------------------|------|
| • Added Conditions note to the ABSOLUTE MAXIMUM RATINGS table "over operating free-air temperature range (unless otherwise noted)" ..... | 5    |
| • Deleted Storage temperature, $T_{stg}$ from the ABSOLUTE MAXIMUM RATINGS table .....                                                   | 5    |
| • Added Receiver output current, $I_O$ to the ABSOLUTE MAXIMUM RATINGS table .....                                                       | 5    |

| <b>Changes from Revision B (June 2003) to Revision C</b>               | <b>Page</b>        |
|------------------------------------------------------------------------|--------------------|
| • Added the THERMAL CHARACTERISTICS table .....                        | <a href="#">7</a>  |
| • Added the THEORY OF OPERATION section .....                          | <a href="#">17</a> |
| • Added the NOISE CONSIDERATIONS FOR EQUALIZED RECEIVERS section ..... | <a href="#">22</a> |

| <b>Changes from Revision A (March 2003) to Revision B</b>                                                                       | <b>Page</b>        |
|---------------------------------------------------------------------------------------------------------------------------------|--------------------|
| • Added $V_{IK}$ Typical Value of 0.75 V (DRIVER ELECTRICAL CHARACTERISTICS table) .....                                        | <a href="#">7</a>  |
| • Deleted $V_{IT(F+)} - V_{CM} = -20\text{ V to } 25\text{ V}$ Minimum value (RECEIVER ELECTRICAL CHARACTERISTICS table) .....  | <a href="#">8</a>  |
| • Added RECEIVER EQUALIZATION CHARACTERISTICS table.....                                                                        | <a href="#">9</a>  |
| • Added <a href="#">Figure 6</a> , <a href="#">Figure 7</a> , and <a href="#">Figure 8</a> to the TYPICAL CHARACTERISTICS ..... | <a href="#">11</a> |
| • Changed A Input circuit in the EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS .....                                           | <a href="#">21</a> |
| • Changed the INTEGRATED RECEIVER EQUALIZATION USING THE SN65HVD23 section .....                                                | <a href="#">23</a> |

| <b>Changes from Original (December 2002) to Revision A</b>                                                                                                                                      | <b>Page</b>       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| • Changed $t_{PZH}$ , $t_{PHZ}$ , $t_{PZL}$ , and $t_{PLZ}$ - From a maximum value of 120 to include typical and maximum values for each entry (RECEIVER SWITCHING CHARACTERISTICS table) ..... | <a href="#">9</a> |

## 5 Description (continued)

The SN65HVD20 device provides high signaling rate (up to 25 Mbps) for interconnecting networks of up to 64 nodes.

The SN65HVD21 device allows up to 256 connected nodes at moderate data rates (up to 5 Mbps). The driver output slew rate is controlled to provide reliable switching with shaped transitions which reduce high-frequency noise emissions.

The SN65HVD22 device has controlled driver output slew rate for low radiated noise in emission-sensitive applications and for improved signal quality with long stubs. Up to 256 SN65HVD22 nodes can be connected at signaling rates up to 500 kbps.

The SN65HVD23 device implements receiver equalization technology for improved jitter performance on differential bus applications with data rates up to 25 Mbps at cable lengths up to 160 meters.

The SN65HVD24 device implements receiver equalization technology for improved jitter performance on differential bus applications with data rates from 1 Mbps to 10 Mbps at cable lengths up to 1000 meters.

The receivers include a failsafe circuit that provides a high-level output within 250 microseconds after loss of the input signal. The most common causes of signal loss are disconnected cables, shorted lines, or the absence of any active transmitters on the bus. This feature prevents noise from being received as valid data under these fault conditions. This feature may be used for Wired-OR bus signaling.

The SN65HVD2x devices are characterized for operation temperatures from –40°C to 85°C.

## 6 Device Options

**Table 1. Product Selection Guide**

| PART NUMBERS | CABLE LENGTH AND SIGNALING RATE <sup>(1)</sup>      | NODES     | MARKING             |
|--------------|-----------------------------------------------------|-----------|---------------------|
| SN65HVD20    | Up to 50 m at 25 Mbps                               | Up to 64  | D: VP20, P: 65HVD20 |
| SN65HVD21    | Up to 150 m at 5 Mbps (with slew rate limit)        | Up to 256 | D: VP21, P: 65HVD21 |
| SN65HVD22    | Up to 1200 m at 500 kbps (with slew rate limit)     | Up to 256 | D: VP22, P: 65HVD22 |
| SN65HVD23    | Up to 160 m at 25 Mbps (with receiver equalization) | Up to 64  | D: VP23, P: 65HVD23 |
| SN65HVD24    | Up to 500 m at 3 Mbps (with receiver equalization)  | Up to 256 | D: VP24, P: 65HVD24 |

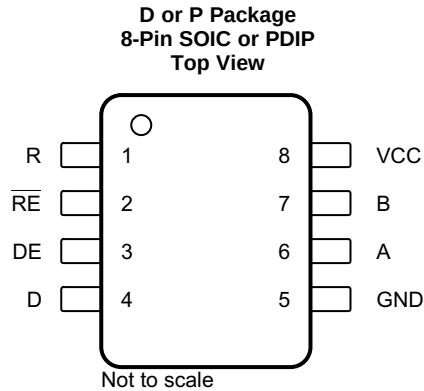
(1) Distance and signaling rate predictions based upon Belden 3105A cable and 15% eye pattern jitter.

**Table 2. Available Options**

| PLASTIC THROUGH-HOLE<br>P-PACKAGE (JEDEC MS-001) | PLASTIC SMALL-OUTLINE <sup>(1)</sup><br>D-PACKAGE (JEDEC MS-012) |
|--------------------------------------------------|------------------------------------------------------------------|
| SN65HVD20P                                       | SN65HVD20D                                                       |
| SN65HVD21P                                       | SN65HVD21D                                                       |
| SN65HVD22P                                       | SN65HVD22D                                                       |
| SN65HVD23P                                       | SN65HVD23D                                                       |
| SN65HVD24P                                       | SN65HVD24D                                                       |

(1) Add R suffix for taped and reeled carriers.

## 7 Pin Configuration and Functions



### Pin Functions

| PIN             |     | I/O                  | DESCRIPTION                                          |
|-----------------|-----|----------------------|------------------------------------------------------|
| NAME            | NO. |                      |                                                      |
| A               | 6   | Bus input and output | Driver output or receiver input (complementary to B) |
| B               | 7   | Bus input and output | Driver output or receiver input (complementary to A) |
| D               | 4   | Digital input        | Driver data input                                    |
| DE              | 3   | Digital input        | Driver enable, active high                           |
| GND             | 5   | Reference potential  | Local device ground                                  |
| R               | 1   | Digital output       | Receive data output                                  |
| $\overline{RE}$ | 2   | Digital input        | Receiver enable, active low                          |
| VCC             | 8   | Supply               | 4.5-V to 5.5-V supply                                |

## 8 Specifications

### 8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                                    |                        |                                                         | MIN                                   | MAX            | UNIT |
|------------------------------------|------------------------|---------------------------------------------------------|---------------------------------------|----------------|------|
| Supply voltage <sup>(2)</sup>      |                        |                                                         | −0.5                                  | 7              | V    |
| Voltage at any bus I/O terminal    |                        |                                                         | −27                                   | 27             | V    |
| Voltage input, transient pulse     | A, B                   | (through 100 $\Omega$ , see <a href="#">Figure 24</a> ) | −60                                   | 60             | V    |
| Voltage input                      | D, DE, $\overline{RE}$ |                                                         | −0.5                                  | $V_{CC} + 0.5$ | V    |
| Receiver output current            |                        |                                                         | −10                                   | 10             | mA   |
| Continuous total power dissipation |                        |                                                         | See <a href="#">Power Dissipation</a> |                |      |
| Junction temperature, $T_J$        |                        |                                                         |                                       | 150            | °C   |
| Storage temperature, $T_{stg}$     |                        |                                                         |                                       | 150            | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.

## 8.2 ESD Ratings

|                    |                         |                                                                                |                             | VALUE  | UNIT |
|--------------------|-------------------------|--------------------------------------------------------------------------------|-----------------------------|--------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>              | All pins except 5, 6, and 7 | ±5000  | V    |
|                    |                         |                                                                                | Pins 5, 6, and 7            | ±16000 |      |
|                    |                         | Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup> |                             | ±1500  |      |
|                    |                         | Machine Model (MM) <sup>(3)</sup>                                              |                             | ±200   |      |

(1) Tested in accordance with JEDEC Standard 22, Test Method A114-A.

(2) Tested in accordance with JEDEC Standard 22, Test Method C101.

(3) Tested in accordance with JEDEC Standard 22, Test Method A115-A.

## 8.3 Recommended Operating Conditions

|          |                                               |                                                                                                               | MIN           | NOM | MAX      | UNIT |
|----------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------|-----|----------|------|
| $V_{CC}$ | Supply voltage                                |                                                                                                               | 4.5           | 5   | 5.5      | V    |
|          | Voltage at any bus I/O terminal               | A, B                                                                                                          | –20           |     | 25       | V    |
| $V_{IH}$ | High-level input voltage                      | D, DE, $\overline{RE}$                                                                                        | 2             |     | $V_{CC}$ | V    |
| $V_{IL}$ | Low-level input voltage                       |                                                                                                               | 0             |     | 0.8      | V    |
| $V_{ID}$ | Differential input voltage                    | A with respect to B                                                                                           | –25           |     | 25       | V    |
|          | Output current                                | Driver                                                                                                        | –110          |     | 110      | mA   |
|          |                                               | Receiver                                                                                                      | –8            |     | 8        |      |
| $I_{CC}$ | Supply current                                | Driver enabled (DE at $V_{CC}$ ),<br>Receiver enabled (RE at 0 V), No load,<br>$V_I = 0$ V or $V_{CC}$        | SN65HVD20     | 6   | 9        | mA   |
|          |                                               |                                                                                                               | SN65HVD21     | 8   | 12       |      |
|          |                                               |                                                                                                               | SN65HVD22     | 6   | 9        |      |
|          |                                               |                                                                                                               | SN65HVD23     | 7   | 11       |      |
|          |                                               |                                                                                                               | SN65HVD24     | 10  | 14       |      |
|          |                                               | Driver enabled (DE at $V_{CC}$ ),<br>Receiver disabled (RE at $V_{CC}$ ), No load,<br>$V_I = 0$ V or $V_{CC}$ | SN65HVD20     | 5   | 8        |      |
|          |                                               |                                                                                                               | SN65HVD21     | 7   | 11       |      |
|          |                                               |                                                                                                               | SN65HVD22     | 5   | 8        |      |
|          |                                               |                                                                                                               | SN65HVD23     | 5   | 9        |      |
|          |                                               |                                                                                                               | SN65HVD24     | 8   | 12       |      |
|          |                                               | Driver disabled (DE at 0 V),<br>Receiver enabled (RE at 0 V), No load                                         | SN65HVD20     | 4   | 7        |      |
|          |                                               |                                                                                                               | SN65HVD21     | 5   | 8        |      |
|          |                                               |                                                                                                               | SN65HVD22     | 4   | 7        |      |
|          |                                               |                                                                                                               | SN65HVD23     | 4.5 | 9        |      |
|          |                                               |                                                                                                               | SN65HVD24     | 5.5 | 10       |      |
|          |                                               | Driver disabled (DE at 0 V), Receiver disabled (RE at $V_{CC}$ ) D open                                       | All SN65HVD2x |     | 1        | μA   |
| $T_A$    | Operating free-air temperature <sup>(1)</sup> |                                                                                                               | –40           |     | 85       | °C   |
| $T_J$    | Junction temperature                          |                                                                                                               | –40           |     | 130      | °C   |

(1) Maximum free-air temperature operation is allowed as long as the device recommended junction temperature is not exceeded.

## 8.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | SN65HVD2x |          | UNIT |
|-------------------------------|----------------------------------------------|-----------|----------|------|
|                               |                                              | D (SOIC)  | P (PDIP) |      |
|                               |                                              | 8 PINS    | 8 PINS   |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 78.1      | 52.5     | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case(top) thermal resistance     | 56.5      | 57.6     | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 50.4      | 38.6     | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 4.1       | 19.1     | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 32.6      | 31.9     | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 8.5 Driver Electrical Characteristics

over recommended operating conditions (unless otherwise noted).<sup>(1)</sup>

| PARAMETER            |                                                                            | TEST CONDITIONS                                                                                 | MIN             | TYP  | MAX      | UNIT    |
|----------------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-----------------|------|----------|---------|
| $V_{IK}$             | Input clamp voltage                                                        | $I_I = -18$ mA                                                                                  | -1.5            | 0.75 |          | V       |
| $V_O$                | Open-circuit output voltage                                                | A or B, No load                                                                                 | 0               |      | $V_{CC}$ | V       |
| $ V_{OD(SS)} $       | Steady-state differential output voltage                                   | No load (open circuit)                                                                          | 3.3             | 4.2  | $V_{CC}$ | V       |
|                      |                                                                            | $R_L = 54$ $\Omega$ , See <a href="#">Figure 9</a>                                              | 1.8             | 2.5  |          |         |
|                      |                                                                            | With common-mode loading, See <a href="#">Figure 10</a>                                         | 1.8             |      |          |         |
| $\Delta V_{OD(SS)} $ | Change in steady-state differential output voltage between logic states    | See <a href="#">Figure 9</a> and <a href="#">Figure 11</a>                                      | -0.1            |      | 0.1      | V       |
| $V_{OC(SS)}$         | Steady-state common-mode output voltage                                    | See <a href="#">Figure 9</a>                                                                    | 2.1             | 2.5  | 2.9      | V       |
| $\Delta V_{OC(SS)}$  | Change in steady-state common-mode output voltage, $V_{OC(H)} - V_{OC(L)}$ | See <a href="#">Figure 9</a> and <a href="#">Figure 12</a>                                      | -0.1            |      | 0.1      | V       |
| $V_{OC(PP)}$         | Peak-to-peak common-mode output voltage, $V_{OC(MAX)} - V_{OC(MIN)}$       | $R_L = 54$ $\Omega$ , $C_L = 50$ pF, See <a href="#">Figure 9</a> and <a href="#">Figure 12</a> | 0.35            |      |          | V       |
| $V_{OD(RING)}$       | Differential output voltage over and under shoot                           | $R_L = 54$ $\Omega$ , $C_L = 50$ pF, See <a href="#">Figure 13</a>                              |                 |      | 10%      |         |
| $I_I$                | Input current                                                              | D, DE                                                                                           | -100            |      | 100      | $\mu$ A |
| $I_O$                | Output current with power off.<br>High impedance state output current.     | $V_O = -7$ V to 12 V,<br>Other input = 0 V                                                      | SN65HVD2[0,3]   |      | 500      | $\mu$ A |
|                      |                                                                            |                                                                                                 | SN65HVD2[1,2,4] |      | 125      |         |
|                      |                                                                            | $V_O = -20$ V to 25 V,<br>Other input = 0 V                                                     | SN65HVD2[0,3]   |      | 1000     |         |
|                      |                                                                            |                                                                                                 | SN65HVD2[1,2,4] |      | 250      |         |
| $I_{OS}$             | Short-circuit output current                                               | $V_O = -20$ V to 25 V, See <a href="#">Figure 17</a>                                            | -250            |      | 250      | mA      |
| $C_{OD}$             | Differential output capacitance                                            |                                                                                                 |                 |      | 20       | pF      |

- (1) All typical values are at  $V_{CC} = 5$  V and 25°C.

## 8.6 Receiver Electrical Characteristics

 over recommended operating conditions (unless otherwise noted)<sup>(1)</sup>

| PARAMETER           |                                                              | TEST CONDITIONS                                                  |                                                | MIN  | TYP  | MAX  | UNIT |
|---------------------|--------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------|------|------|------|------|
| V <sub>IT(+)</sub>  | Positive-going differential input voltage threshold          | See Figure 18                                                    | V <sub>O</sub> = 2.4 V, I <sub>O</sub> = –8 mA |      | 60   | 200  | mV   |
| V <sub>IT(–)</sub>  | Negative-going differential input voltage threshold          |                                                                  | V <sub>O</sub> = 0.4 V, I <sub>O</sub> = 8 mA  | –200 | –60  |      |      |
| V <sub>HYS</sub>    | Hysteresis voltage (V <sub>IT+</sub> – V <sub>IT–</sub> )    |                                                                  |                                                | 100  | 130  |      | mV   |
| V <sub>IT(F+)</sub> | Positive-going differential input failsafe voltage threshold | See Figure 23                                                    | VCM = –7 V to 12 V                             | 40   | 120  | 200  | mV   |
|                     |                                                              |                                                                  | VCM = –20 V to 25 V                            |      | 120  | 250  |      |
| V <sub>IT(F–)</sub> | Negative-going differential input failsafe voltage threshold | See Figure 23                                                    | VCM = –7 V to 12 V                             | –200 | –120 | –40  | mV   |
|                     |                                                              |                                                                  | VCM = –20 V to 25 V                            | –250 | –120 |      |      |
| V <sub>IK</sub>     | Input clamp voltage                                          | I <sub>I</sub> = –18 mA                                          |                                                | –1.5 |      |      | V    |
| V <sub>OH</sub>     | High-level output voltage                                    | V <sub>ID</sub> = 200 mV, I <sub>OH</sub> = –8 mA, See Figure 19 |                                                | 4    |      |      | V    |
| V <sub>OL</sub>     | Low-level output voltage                                     | V <sub>ID</sub> = –200 mV, I <sub>OL</sub> = 8 mA, See Figure 19 |                                                |      |      | 0.4  | V    |
| I <sub>I(BUS)</sub> | Bus input current (power on or power off)                    | V <sub>I</sub> = –7 to 12 V,<br>Other input = 0 V                | SN65HVD2[0,3]                                  | –400 |      | 500  | μA   |
|                     |                                                              |                                                                  | SN65HVD2[1,2,4]                                | –100 |      | 125  |      |
|                     |                                                              | V <sub>I</sub> = –20 to 25 V,<br>Other input = 0 V               | SN65HVD2[0,3]                                  | –800 |      | 1000 |      |
|                     |                                                              |                                                                  | SN65HVD2[1,2,4]                                | –200 |      | 250  |      |
| I <sub>I</sub>      | Input current                                                | $\overline{RE}$                                                  |                                                | –100 |      | 100  | μA   |
| R <sub>I</sub>      | Input resistance                                             | SN65HVD2[0,3]                                                    |                                                | 24   |      |      | kΩ   |
|                     |                                                              | SN65HVD2[1,2,4]                                                  |                                                | 96   |      |      |      |
| C <sub>ID</sub>     | Differential input capacitance                               | V <sub>ID</sub> = 0.5 + 0.4 sine (2π × 1.5 × 10 <sup>6</sup> t)  |                                                |      | 20   |      | pF   |

 (1) All typical values are at V<sub>CC</sub> = 5 V and 25°C.

## 8.7 Driver Switching Characteristics

 over recommended operating conditions (unless otherwise noted)<sup>(1)</sup>

| PARAMETER                           |                                                                                                     | TEST CONDITIONS                                              |               | MIN | TYP | MAX | UNIT |
|-------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------|-----|-----|-----|------|
| t <sub>PLH</sub> , t <sub>PHL</sub> | Differential output propagation delay, low-to-high and high-to-low                                  | R <sub>L</sub> = 54 Ω, C <sub>L</sub> = 50 pF, See Figure 11 | SN65HVD2[0,3] | 6   | 10  | 20  | ns   |
|                                     |                                                                                                     |                                                              | SN65HVD2[1,4] | 20  | 32  | 60  |      |
|                                     |                                                                                                     |                                                              | SN65HVD22     | 160 | 280 | 500 |      |
| t <sub>r</sub> , t <sub>f</sub>     | Differential output rise time and fall time                                                         | R <sub>L</sub> = 54 Ω, C <sub>L</sub> = 50 pF, See Figure 11 | SN65HVD2[0,3] | 2   | 6   | 12  | ns   |
|                                     |                                                                                                     |                                                              | SN65HVD2[1,4] | 20  | 40  | 60  |      |
|                                     |                                                                                                     |                                                              | SN65HVD22     | 200 | 400 | 600 |      |
| t <sub>PZH</sub> , t <sub>PHZ</sub> | Propagation delay time, high-impedance-to-high-level output and high-level output-to-high-impedance | $\overline{RE}$ at 0 V, See Figure 14                        | SN65HVD2[0,3] |     |     | 40  | ns   |
|                                     |                                                                                                     |                                                              | SN65HVD2[1,4] |     |     | 100 |      |
|                                     |                                                                                                     |                                                              | SN65HVD22     |     |     | 300 |      |
| t <sub>PZL</sub> , t <sub>PLZ</sub> | Propagation delay time, high-impedance-to-high-level output and high-level output-to-high-impedance | $\overline{RE}$ at 0 V, See Figure 15                        | SN65HVD2[0,3] |     |     | 40  | ns   |
|                                     |                                                                                                     |                                                              | SN65HVD2[1,4] |     |     | 100 |      |
|                                     |                                                                                                     |                                                              | SN65HVD22     |     |     | 300 |      |
| t <sub>d(standby)</sub>             | Time from an active differential output to standby                                                  | $\overline{RE}$ at V <sub>CC</sub> , See Figure 16           |               |     |     | 2   | μs   |
| t <sub>d(wake)</sub>                | Wake-up time from standby to an active differential output                                          |                                                              |               |     |     | 8   | μs   |
| t <sub>sk(p)</sub>                  | Pulse skew   t <sub>PLH</sub> – t <sub>PHL</sub>                                                    | SN65HVD2[0,3]                                                |               |     |     | 2   | ns   |
|                                     |                                                                                                     | SN65HVD2[1,4]                                                |               |     |     | 6   |      |
|                                     |                                                                                                     | SN65HVD22                                                    |               |     |     | 50  |      |

 (1) All typical values are at V<sub>CC</sub> = 5 V and 25°C

## 8.8 Receiver Switching Characteristics

over recommended operating conditions (unless otherwise noted)

| PARAMETER        |                                                                               | TEST CONDITIONS                   |                 | MIN | TYP | MAX | UNIT    |
|------------------|-------------------------------------------------------------------------------|-----------------------------------|-----------------|-----|-----|-----|---------|
| $t_{PLH}$        | Propagation delay time, low-to-high level output and high-to low level output | See Figure 19                     | SN65HVD2[0,3]   |     | 16  | 35  | ns      |
| $t_{PHL}$        |                                                                               |                                   | SN65HVD2[1,2,4] |     | 25  | 50  |         |
| $t_r$            | Receiver output rise time                                                     | See Figure 19                     |                 |     | 2   | 4   | ns      |
| $t_f$            | Receiver output fall time                                                     |                                   |                 |     |     |     |         |
| $t_{PZH}$        | Receiver output enable time to high level and disable time from high level    | See Figure 20                     |                 |     | 90  | 120 | ns      |
| $t_{PHZ}$        |                                                                               |                                   |                 |     | 16  | 35  |         |
| $t_{PZL}$        | Receiver output enable time to low level and disable time from low level      | See Figure 21                     |                 |     | 90  | 120 | ns      |
| $t_{PLZ}$        |                                                                               |                                   |                 |     | 16  | 35  |         |
| $t_{r(standby)}$ | Time from an active receiver output to standby                                | See Figure 22, DE at 0 V          |                 |     |     | 2   | $\mu$ s |
| $t_{r(wake)}$    | Wake-up time from standby to an active receiver output                        | See Figure 22, DE at 0 V          |                 |     |     | 8   | $\mu$ s |
| $t_{sk(p)}$      | Pulse skew $ t_{PLH} - t_{PHL} $                                              |                                   |                 |     |     | 5   | ns      |
| $t_{p(set)}$     | Delay time, bus fail to failsafe set                                          | See Figure 23, pulse rate = 1 kHz |                 |     | 250 | 350 | $\mu$ s |
| $t_{p(reset)}$   | Delay time, bus recovery to failsafe reset                                    | See Figure 23, pulse rate = 1 kHz |                 |     | 50  |     | ns      |

## 8.9 Receiver Equalization Characteristics<sup>(1)</sup>

over recommended operating conditions (unless otherwise noted)<sup>(2)</sup>

| PARAMETER   |                                 | TEST CONDITIONS                                                                                      |         |        |           | TYP | UNIT |
|-------------|---------------------------------|------------------------------------------------------------------------------------------------------|---------|--------|-----------|-----|------|
| $t_{j(pp)}$ | Peak-to-peak eye-pattern jitter | Pseudo-random NRZ code with a bit pattern length of $2^{16} - 1$ , Belden 3105A cable, See Figure 26 | 25 Mbps | 0 m    | SN65HVD23 | 2   | ns   |
|             |                                 |                                                                                                      |         | 100 m  | SN65HVD20 | 6   | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 3   |      |
|             |                                 |                                                                                                      |         | 150 m  | SN65HVD20 | 15  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 4   |      |
|             |                                 |                                                                                                      |         | 200 m  | SN65HVD20 | 27  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 8   |      |
|             |                                 |                                                                                                      | 10 Mbps | 200 m  | SN65HVD20 | 22  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 8   |      |
|             |                                 |                                                                                                      |         | 250 m  | SN65HVD20 | 34  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 15  |      |
|             |                                 |                                                                                                      |         | 300 m  | SN65HVD20 | 49  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 27  |      |
|             |                                 |                                                                                                      | 5 Mbps  | 500 m  | SN65HVD21 | 128 | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD24 | 18  |      |
|             |                                 |                                                                                                      | 3 Mbps  | 500 m  | SN65HVD20 | 93  | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD21 | 103 |      |
|             |                                 |                                                                                                      |         |        | SN65HVD23 | 90  |      |
|             |                                 |                                                                                                      |         |        | SN65HVD24 | 16  |      |
|             |                                 |                                                                                                      | 1 Mbps  | 1000 m | SN65HVD21 | 216 | ns   |
|             |                                 |                                                                                                      |         |        | SN65HVD24 | 62  |      |

(1) The SN65HVD20 and SN65HVD21 do not have receiver equalization, but are specified for comparison.

(2) All typical values are at  $V_{CC} = 5$  V, and temperature = 25°C.

## 8.10 Power Dissipation

| PARAMETERS      |                                        | TEST CONDITIONS |                                                                                                                                                                                                                     |                     | VALUE | UNIT |
|-----------------|----------------------------------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|------|
| P <sub>D</sub>  | Device power dissipation               | Typical         | V <sub>CC</sub> = 5 V, T <sub>J</sub> = 25°C,<br>R <sub>L</sub> = 54 Ω, C <sub>L</sub> = 50 pF (driver),<br>C <sub>L</sub> = 15 pF (receiver),<br>50% Duty cycle square-wave signal,<br>Driver and receiver enabled | SN65HVD20: 25 Mbps  | 295   | mW   |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD21: 5 Mbps   | 260   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD22: 500 kbps | 233   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD23: 25 Mbps  | 302   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD24: 5 Mbps   | 267   |      |
|                 |                                        | Worst case      | V <sub>CC</sub> = 5.5 V, T <sub>J</sub> = 125°C,<br>R <sub>L</sub> = 54 Ω, C <sub>L</sub> = 50 pF,<br>C <sub>L</sub> = 15 pF (receiver),<br>50% Duty cycle square-wave signal,<br>Driver and receiver enabled       | SN65HVD20: 25 Mbps  | 408   | mW   |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD21: 5 Mbps   | 342   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD22: 500 kbps | 300   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD23: 25 Mbps  | 417   |      |
|                 |                                        |                 |                                                                                                                                                                                                                     | SN65HVD24: 5 Mbps   | 352   |      |
| T <sub>SD</sub> | Thermal shut down junction temperature |                 |                                                                                                                                                                                                                     |                     | 170   | °C   |

## 8.11 Typical Characteristics

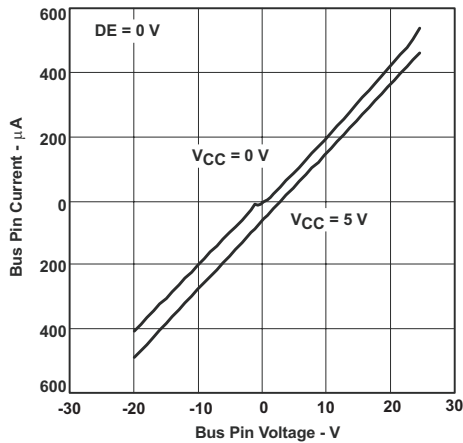


Figure 1. SN65HVD2[0,3] Bus Pin Current vs Bus Pin Voltage

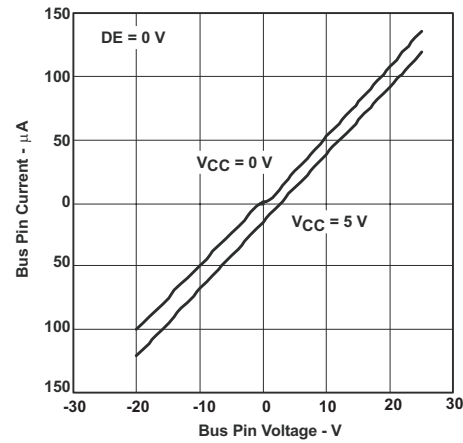


Figure 2. SN65HVD2[1,2,4] Bus Pin Current vs Bus Pin Voltage

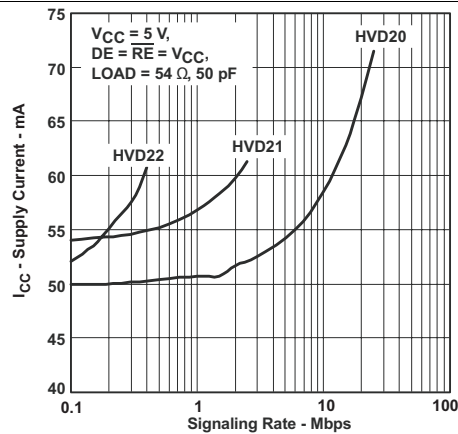


Figure 3. Supply Current vs Signaling Rate

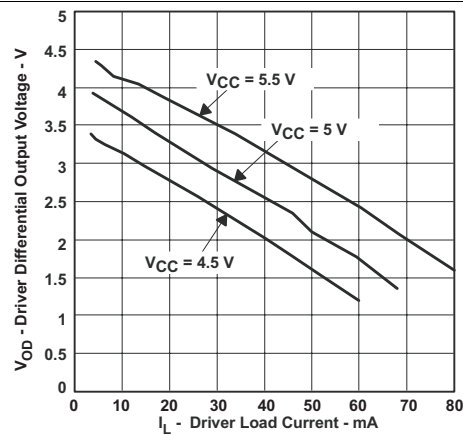


Figure 4. Driver Differential Output Voltage vs Driver Load Current

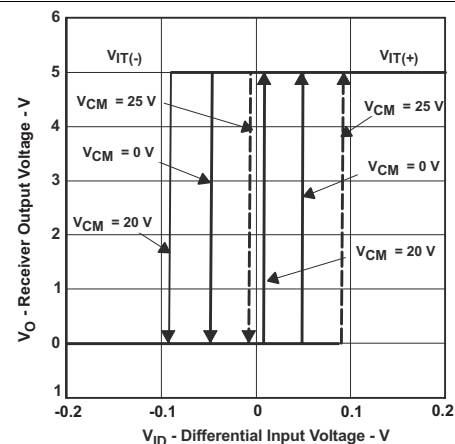


Figure 5. Receiver Output Voltage vs Differential Input Voltage

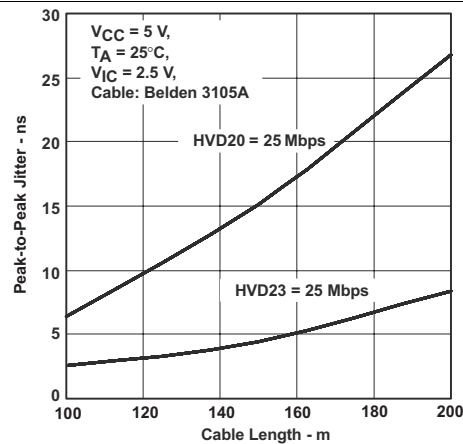


Figure 6. SN65HVD2[0,3] Peak-to-Peak Jitter vs Cable Length

## Typical Characteristics (continued)

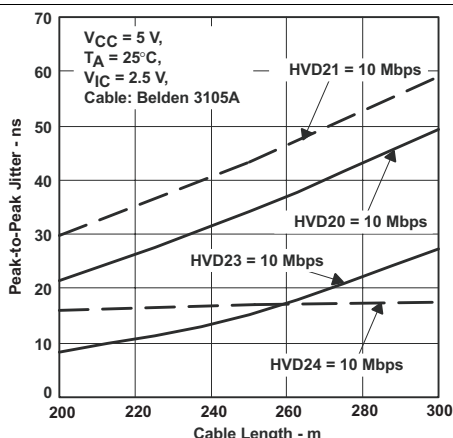


Figure 7. SN65HVD2[0,1,3,4] Peak-to-Peak Jitter vs Cable Length

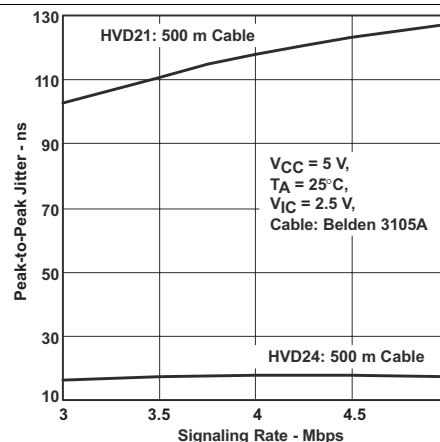


Figure 8. SN65HVD2[1,4] Peak-to-Peak Jitter vs Signaling Rate

## 9 Parameter Measurement Information

### NOTE

Test load capacitance includes probe and jig capacitance (unless otherwise specified). Signal generator characteristics: rise and fall time  $< 6\text{ ns}$ , pulse rate 100 kHz, 50% duty cycle,  $Z_o = 50\ \Omega$  (unless otherwise specified).

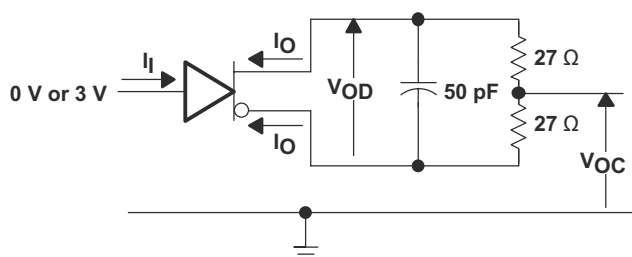


Figure 9. Driver Test Circuit,  $V_{OD}$  and  $V_{OC}$  Without Common-Mode Loading

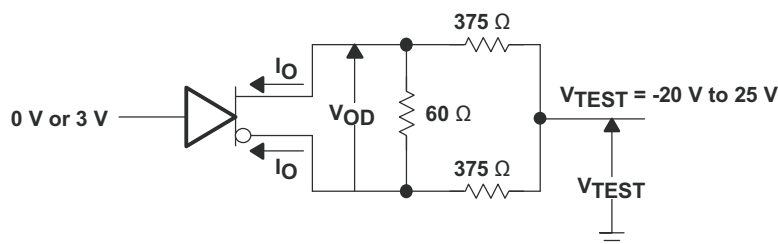


Figure 10. Driver Test Circuit,  $V_{OD}$  With Common-Mode Loading

## Parameter Measurement Information (continued)

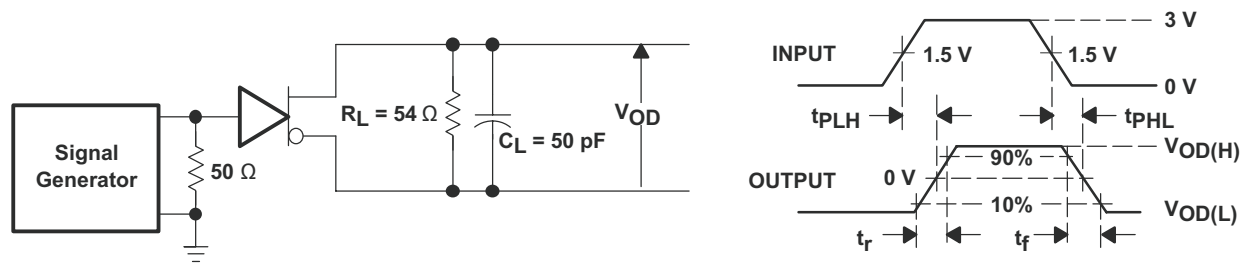


Figure 11. Driver Switching Test Circuit and Waveforms

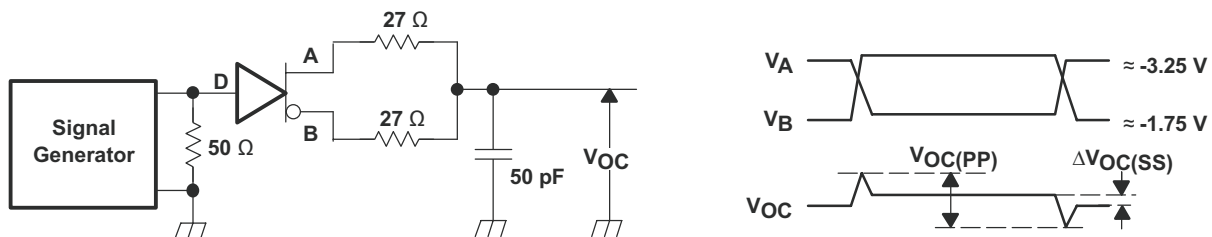
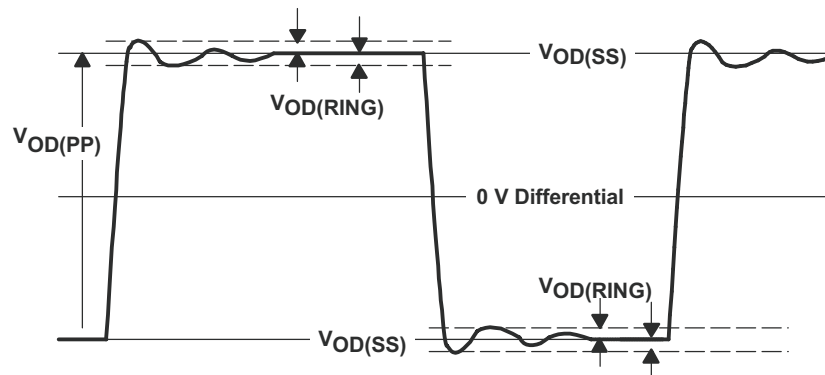


Figure 12. Driver  $V_{OC}$  Test Circuit and Waveforms



$V_{OD(RING)}$  is measured at four points on the output waveform, corresponding to overshoot and undershoot from the  $V_{OD(H)}$  and  $V_{OD(L)}$  steady state values.

Figure 13.  $V_{OD(RING)}$  Waveform and Definitions

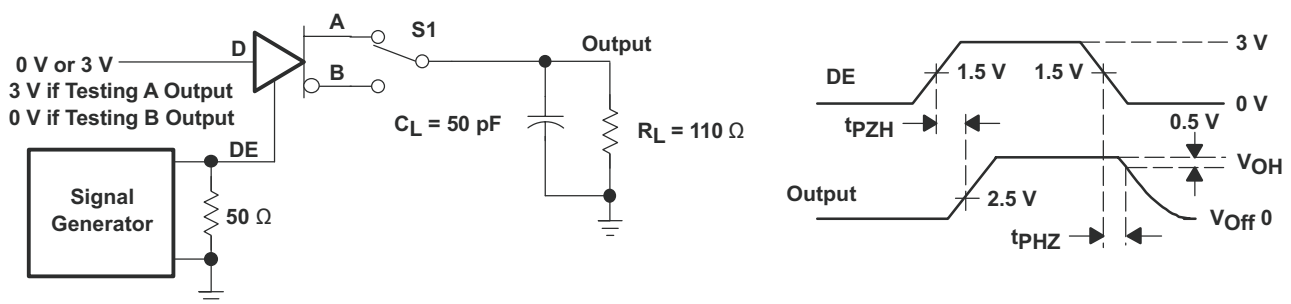
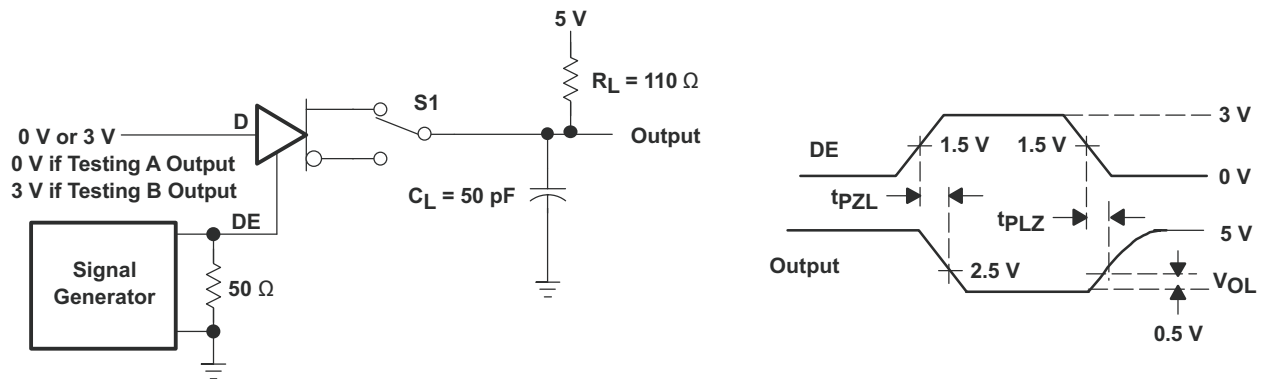
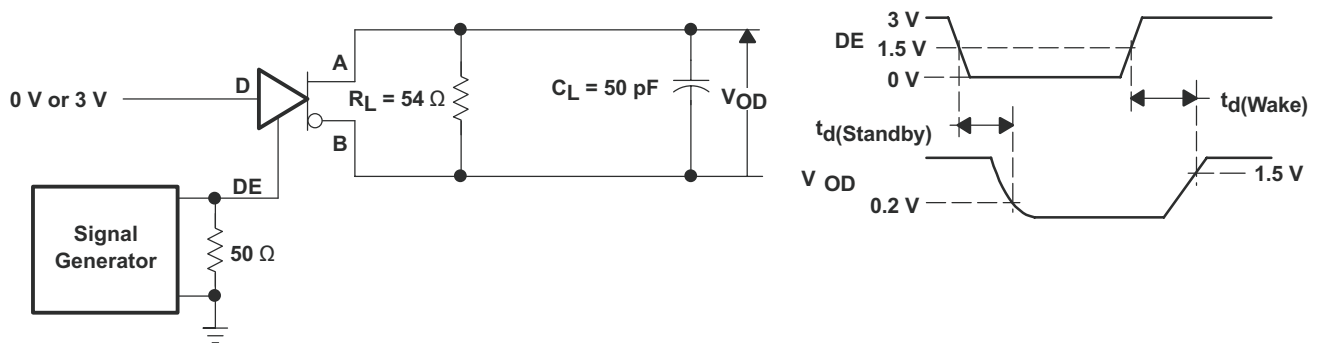
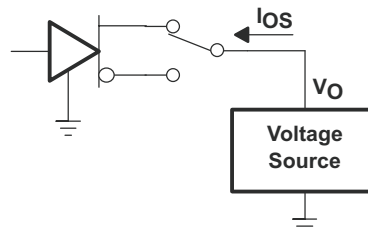
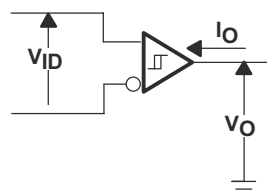


Figure 14. Driver Enable and Disable Test, High Output

**Parameter Measurement Information (continued)**

**Figure 15. Driver Enable and Disable Test, Low Output**

**Figure 16. Driver Standby and Wake Test Circuit and Waveforms**

**Figure 17. Driver Short-Circuit Test**

**Figure 18. Receiver DC Parameter Definitions**

## Parameter Measurement Information (continued)

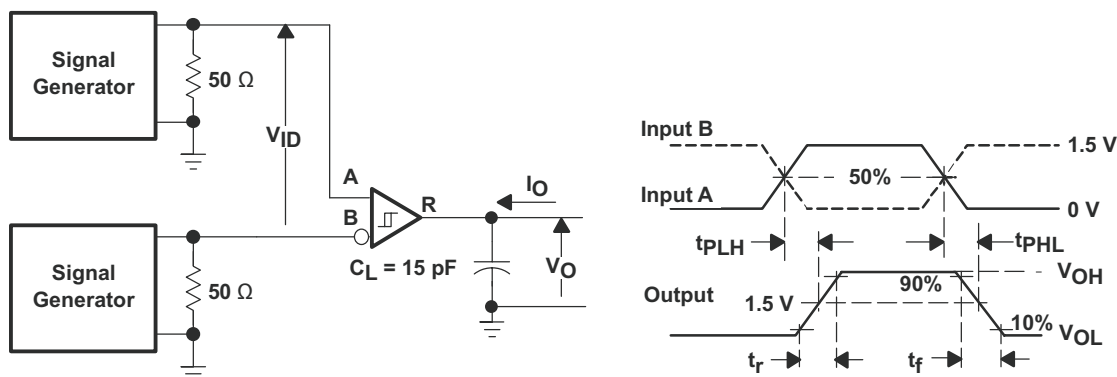


Figure 19. Receiver Switching Test Circuit and Waveforms

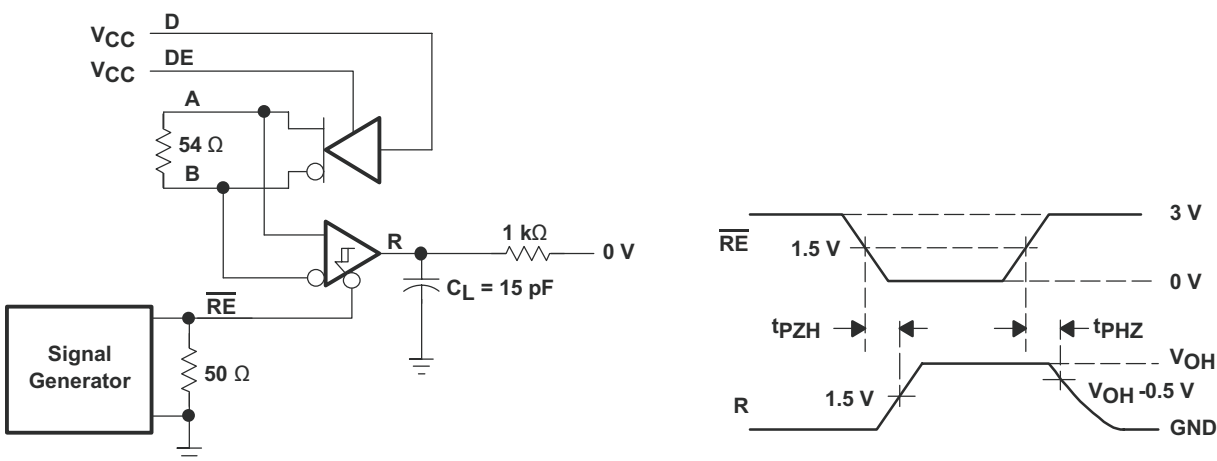


Figure 20. Receiver Enable Test Circuit and Waveforms, Data Output High

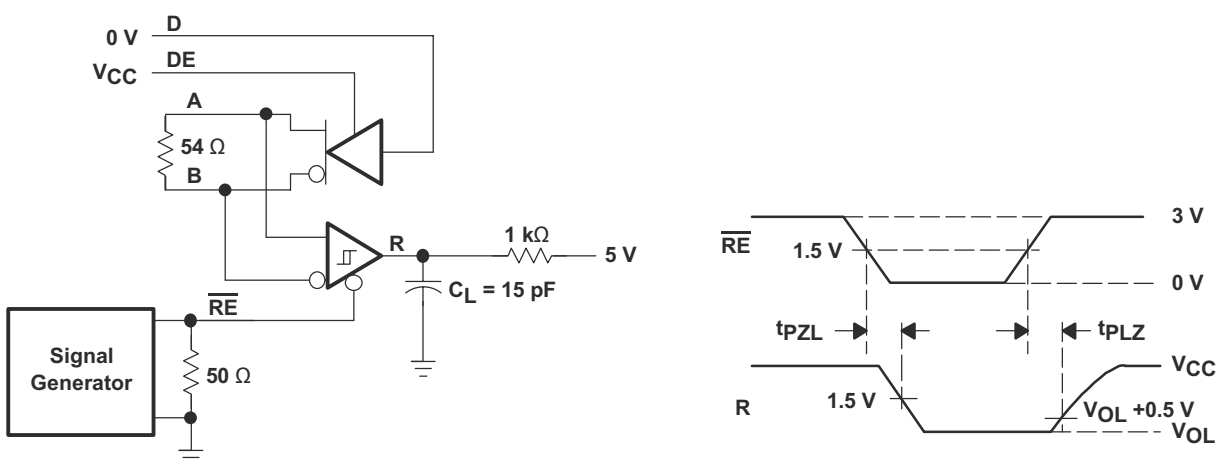
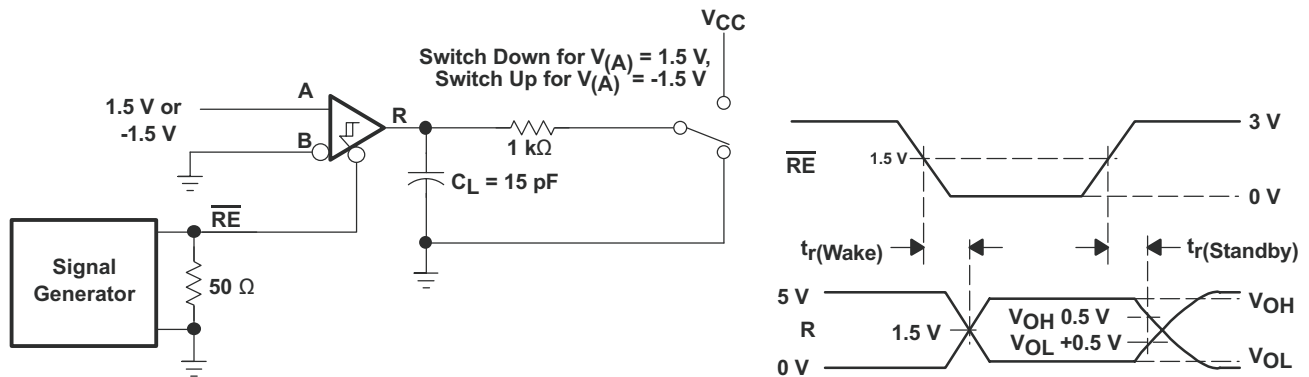
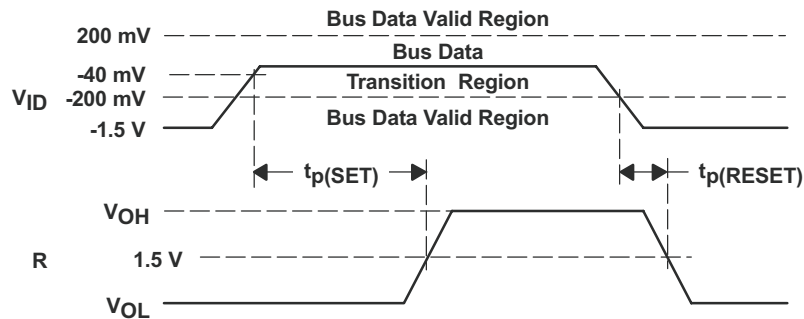
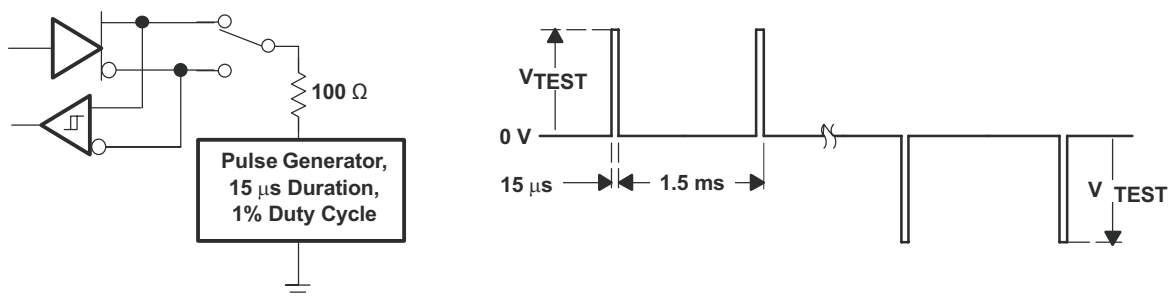


Figure 21. Receiver Enable Test Circuit and Waveforms, Data Output Low

**Parameter Measurement Information (continued)**

**Figure 22. Receiver Standby and Wake Test Circuit and Waveforms**

**Figure 23. Receiver Active Failsafe Definitions and Waveforms**

**Figure 24. Test Circuit and Waveforms, Transient Overvoltage Test**



## Feature Description (continued)

If both the driver and receiver are disabled, ( $\overline{\text{DE}}$  low and  $\overline{\text{RE}}$  high) then all nonessential circuitry, including auxiliary functions such as failsafe and receiver equalization is placed in a low-power standby state. This reduces power consumption to less than 5  $\mu\text{W}$ . When either enable input is asserted, the circuitry again becomes active.

In addition to the primary differential receiver, these devices incorporate a set of comparators and logic to implement an active receiver failsafe feature. These components determine whether the differential bus signal is valid. Whenever the differential signal is close to zero volts (neither high nor low), a timer initiates. If the differential input remains within the transition range for more than 250  $\mu\text{s}$ , the timer expires and set the receiver output to the high state. If a valid bus input (high or low) is received at any time, the receiver output reflects the valid bus state, and the timer is reset.

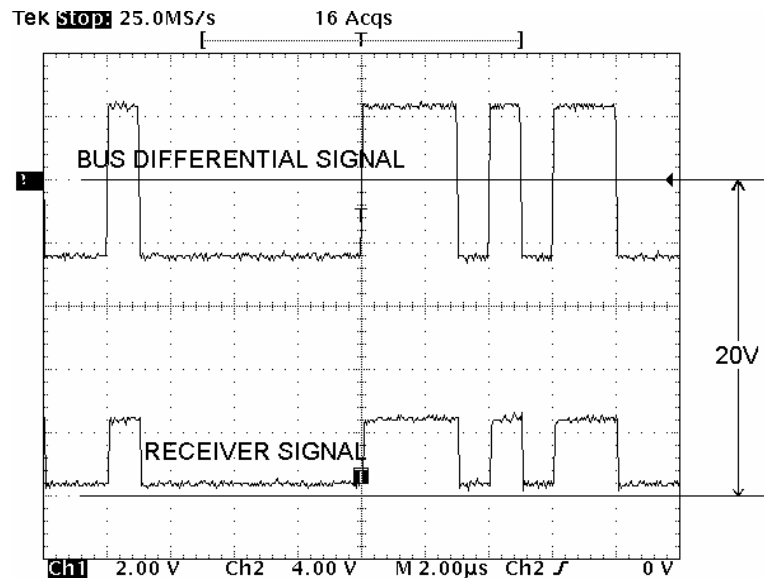


Figure 25. SN65HVD22 Receiver Operation With 20-V Offset on Input Signal

| $H(s) = k_0 \left[ (1-k_1) + \frac{k_1 p_1}{(s + p_1)} \right] \left[ (1-k_2) + \frac{k_2 p_2}{(s + p_2)} \right] \left[ (1-k_3) + \frac{k_3 p_3}{(s + p_3)} \right]$ | $k_0$<br>(DC loss) | $p_1$<br>(MHz) | $k_1$ | $p_2$<br>(MHz) | $k_2$ | $p_3$<br>(MHz) | $k_3$ |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------|-------|----------------|-------|----------------|-------|
| Similar to 160m of Belden 3105A                                                                                                                                       | 0.95               | 0.25           | 0.3   | 3.5            | 0.5   | 15             | 1     |
| Similar to 250m of Belden 3105A                                                                                                                                       | 0.9                | 0.25           | 0.4   | 3.5            | 0.7   | 12             | 1     |
| Similar to 500m of Belden 3105A                                                                                                                                       | 0.8                | 0.25           | 0.6   | 2.2            | 1     | 8              | 1     |
| Similar to 1000m of Belden 3105A                                                                                                                                      | 0.6                | 0.3            | 1     | 3              | 1     | 6              | 1     |

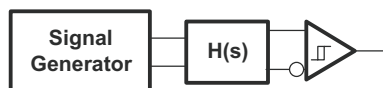


Figure 26. Cable Attenuation Model for Jitter Measurements

## 10.4 Device Functional Modes

The driver and receiver behavior for different input conditions are shown in [Table 3](#) and [Table 4](#), respectively.

**Table 3. Driver Function Table<sup>(1)</sup>**

| DEVICE          | INPUT | ENABLE | OUTPUTS |   |
|-----------------|-------|--------|---------|---|
|                 | D     | DE     | A       | B |
| SN65HVD2[0,1,2] | H     | H      | H       | L |
|                 | L     | H      | L       | H |
|                 | X     | L      | Z       | Z |
|                 | X     | OPEN   | Z       | Z |
|                 | OPEN  | H      | H       | L |
| SN65HVD2[3,4]   | H     | H      | H       | L |
|                 | L     | H      | L       | H |
|                 | X     | L      | Z       | Z |
|                 | X     | OPEN   | Z       | Z |
|                 | OPEN  | H      | L       | H |

(1) Legend: H = high level, L = low level, X = don't care, Z = high impedance (off), ? = indeterminate

**Table 4. Receiver Function Table<sup>(1)</sup>**

| DIFFERENTIAL INPUT<br>$V_{ID} = (V_A - V_B)$ | ENABLE<br>$\overline{RE}$ | OUTPUT<br>R      |
|----------------------------------------------|---------------------------|------------------|
| $0.2\text{ V} \leq V_{ID}$                   | L                         | H                |
| $-0.2\text{ V} < V_{ID} < 0.2\text{ V}$      | L                         | H <sup>(2)</sup> |
| $V_{ID} \leq -0.2\text{ V}$                  | L                         | L                |
| X                                            | H                         | Z                |
| X                                            | OPEN                      | Z                |
| Open circuit                                 | L                         | H                |
| Short Circuit                                | L                         | H                |
| Idle (terminated) bus                        | L                         | H                |

(1) H = high level, L = low level, Z = high impedance (off)

(2) If the differential input  $V_{ID}$  remains within the transition range for more than 250  $\mu\text{s}$ , the integrated failsafe circuitry detects a bus fault, and set the receiver output to a high state. See [Figure 23](#).

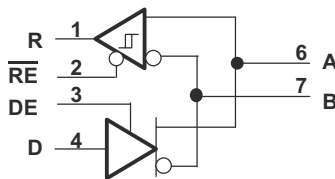


**Figure 27. Logic Diagram**

#### 10.4.1 Test Mode Driver Disable

If the input signal to the D pin is such that:

1. the signal has signaling rate above 4 Mbps (for the SN65HVD21 and SN65HVD24),
2. the signal has signaling rate above 6 Mbps (for the SN65HVD20 and SN65HVD23),
3. the signal has average amplitude from 1.2 V to 1.6 V ( $1.4\text{ V} \pm 200\text{ mV}$ ), or
4. the average signal amplitude remains in this range for 100  $\mu\text{s}$  or longer,

then the driver may activate a test-mode during which the driver outputs are temporarily disabled. This can cause loss of transmission of data during the period that the device is in the test-mode. The driver is re-enabled and resumes normal operation whenever the above conditions are not true. The device is not damaged by this test mode.

Although rare, there are combinations of specific voltage levels and input data patterns within the operating conditions of the SN65HVD2x family which may lead to a temporary state where the driver outputs are disabled for a period of time.

Observations:

1. The conditions for inadvertently entering the test mode are dependent on the levels, duration, and duty cycle of the logic signal input to the D pin. Operating input levels are specified as greater than 2 V for a logic HIGH input, and less than 0.8 V for a logic LOW input. Therefore, a valid steady-state logic input does not cause the device to activate the test mode
2. Only input signals with frequency content above 2 MHz (4 Mbps) have a possibility of activating the test mode. Therefore, this issue should not affect the normal operation of the SN65HVD22 (500 kbps).
3. For operating signaling rates of 4 Mbps (or above), the conditions stated above must remain true over a period of:  $4\text{ Mbps} \times 100\text{ }\mu\text{s} = 400\text{ bits}$ . Therefore, a normal short message does not inadvertently activate the test model.
4. One example of an input signal which may cause the test mode to activate is a clock signal with frequency 3 MHz and 50% duty cycle (symmetric HIGH and LOW half-cycles) with logic HIGH levels of 2.4 V and logic LOW levels of 0.4 V. This signal applied to the D pin as a driver input would meet the criteria listed above, and may cause the test-mode to activate, which would disable the driver. This example situation may occur if the clock signal is generated from a microcontroller or logic chip with a 2.7-V supply.

### 10.4.2 Equivalent Input and Output Schematic Diagrams

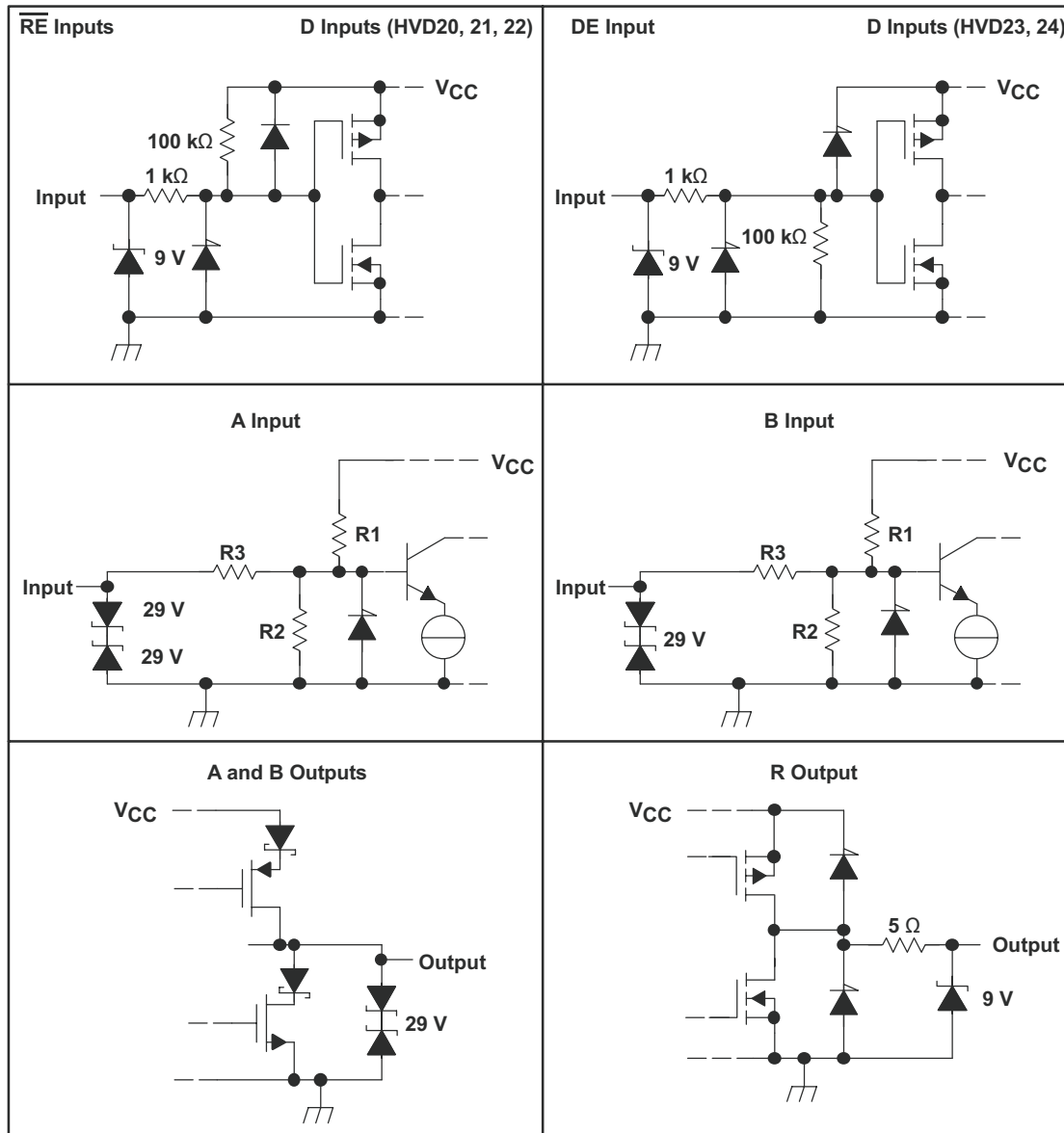


Figure 28. Equivalent Input and Output Schematic Diagrams

Table 5. Input and Output Resistor Values

| DEVICE          | R1, R2 | R3     |
|-----------------|--------|--------|
| SN65HVD2[0,3]   | 9 kΩ   | 45 kΩ  |
| SN65HVD2[1,2,4] | 36 kΩ  | 180 kΩ |

## 11 Application and Implementation

### NOTE

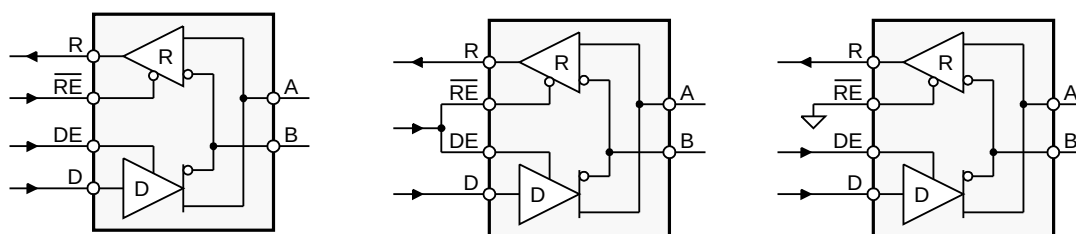
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 11.1 Application Information

The SN65HVD2x devices are half-duplex RS-485 transceivers that can be used for bidirectional, multipoint communication at various data rates over differential transmission lines. These devices support a wide common-mode range, allowing for robust communication even in the presence of voltage differences between the reference potentials of different nodes on a network.

### 11.2 Typical Application

Figure 29 shows a typical RS-485 application. Transceivers of different nodes are connected to one another over a shared bus. Twisted-pair cabling with a controlled differential impedance is used, and termination resistances are placed at the two ends of the cable to match the transmission line impedance and minimize signal reflections.



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**Figure 29. Half-Duplex Transceiver Configurations**

#### 11.2.1 Design Requirements

As the distances between nodes in an RS-485 network become greater and greater, it becomes more of a challenge to ensure reliable communication. The increased distance often means that the reference (ground) potentials has more of a difference between nodes. These ground potential differences give rise to differences in the common-mode voltages seen by the various transceivers on the bus. Standard RS-485 transceivers are typically specified to operate over a common-mode voltage from  $-7\text{ V}$  to  $12\text{ V}$ , which may be insufficient for larger distances. The SN65HVD2x family of devices extends this range to  $-20\text{ V}$  to  $25\text{ V}$ , allowing for greater communication distances between nodes.

Increased cable lengths can lead to increased jitter, especially in links operating at high data rates. This increased jitter is due to the attenuation of the cable, which tends to increase with frequency. Having unequal loss between higher and lower frequencies causes the RS-485 signal to distort, adding some timing deviation (jitter) to the edge crossings of the RS-485 data. If the jitter amplitude exceeds the jitter tolerance of the receiving MCU or UART, then bit errors are likely to result in the link. However, jitter can be reduced for a given link through the use of receiver equalization.

#### 11.2.2 Detailed Design Procedure

##### 11.2.2.1 Noise Considerations for Equalized Receivers

The simplest way of overcoming the effects of cable losses is to increase the sensitivity of the receiver. If the maximum attenuation of frequencies of interest is  $20\text{ dB}$ , increasing the receiver gain by a factor of ten compensates for the cable. However, this means that signal and noise are amplified. Therefore, the receiver with higher gain is more sensitive to noise and it is important to minimize differential noise coupling to the equalized receiver.

## Typical Application (continued)

Differential noise is created when conducted or radiated noise energy generates more voltage on one line of the differential pair than the other. For this to occur from conducted or electric far-field noise, the impedance to ground of the lines must differ.

For noise frequency out to 50 MHz, the input traces can be treated as a lumped capacitance if the receiver is approximately 10 inches or less from the connector. Therefore, matching impedance of the lines is accomplished by matching the lumped capacitance of each.

The primary factors that affect the capacitance of a trace are in length, thickness, width, dielectric material, distance from the signal return path, stray capacitance, and proximity to other conductors. It is difficult to match each of the variables for each line of the differential pair exactly, but a reasonable effort to do so keeps the lines balanced and less susceptible to differential noise coupling.

Another source of differential noise is from near-field coupling. In this situation, an assumption of equal noise-source impedance cannot be made as in the far-field. Familiarly known as crosstalk, more energy from a nearby signal is coupled to one line of the differential pair. Minimization of this differential noise is accomplished by keeping the signal pair close together and physical separation from high-voltage, high-current, or high-frequency signals.

In summary, follow these guidelines in board layout for keeping differential noise to a minimum.

- Keep the differential input traces short.
- Match the length, physical dimensions, and routing of each line of the pair.
- Keep the lines close together.
- Match components connected to each line.
- Separate the inputs from high-voltage, high-frequency, or high-current signals.

### 11.2.3 Application Curves

**Figure 30** illustrates the benefits of integrated receiver equalization as implemented in the SN65HVD23 transceiver. In this test setup, a differential signal generator applied a signal voltage at one end of the cable, which was Belden 3105A twisted-pair shielded cable. The test signal was a pseudo-random bit stream (PRBS) of nonreturn-to-zero (NRZ) data. Channel 1 (top) shows the eye-pattern of the differential voltage at the receiver inputs (after the cable attenuation). Channel 2 (bottom) shows the output of the receiver.

**Figure 31** illustrates the benefits of integrated receiver equalization as implemented in the SN65HVD24 transceiver. In this test setup, a differential signal generator applied a signal voltage at one end of the cable, which was Belden 3105A twisted-pair shielded cable. The test signal was a pseudo-random bit stream (PRBS) of nonreturn-to-zero (NRZ) data. Channel 1 (top) shows the eye-pattern of the bit stream. Channel 2 (middle) shows the eye-pattern of the differential voltage at the receiver inputs (after the cable attenuation). Channel 3 (bottom) shows the output of the receiver.

## Typical Application (continued)

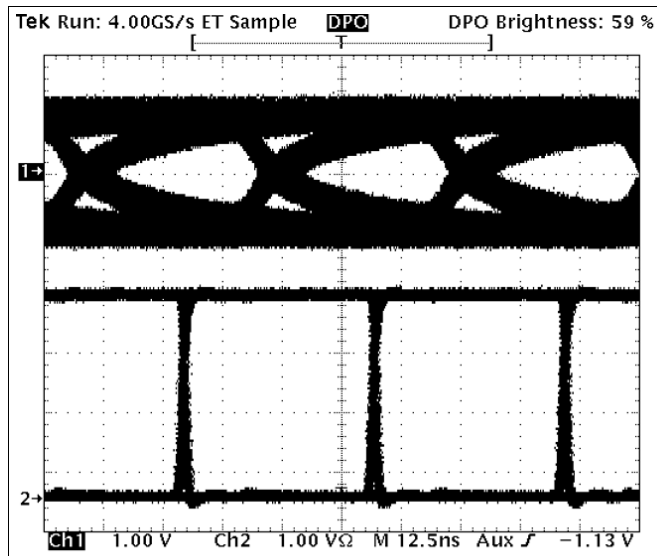


Figure 30. SN65HVD23 Receiver Performance at 25 Mbps Over 150 Meter Cable

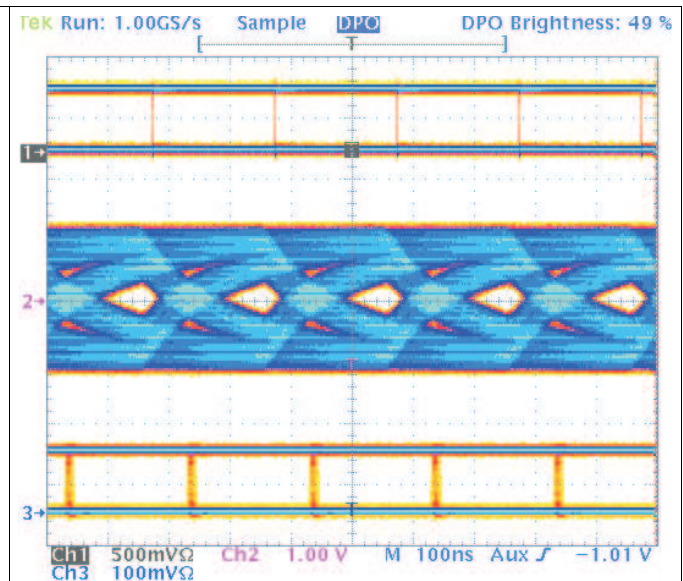


Figure 31. SN65HVD24 Receiver Performance at 5 Mbps Over 500 Meter Cable

## 12 Power Supply Recommendations

To ensure reliable operation at all data rates and supply voltages, each supply must be decoupled with a 100-nF ceramic capacitor placed as close to the supply pins as possible. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes.

## 13 Layout

### 13.1 Layout Guidelines

In addition to the guidelines on differential trace matching given in [Detailed Design Procedure](#), the layout guidelines below must be followed:

- Route power and ground nets as planes rather than traces, and keep their widths as large as possible to minimize resistance and inductance while maximizing parasitic capacitance.
- If external components (like transient voltage suppression diodes) are used for transient protection, place them close to the connector port and within the path of the signal lines. Make sure component capacitances are small enough not to impact the RS-485 signaling at the chosen data rate.
- Small-valued series pulse-proof resistances can be used to provide additional immunity to transients. This is needed to limit input currents if the clamping voltages of external transient protection devices exceed the absolute maximum ratings of the transceiver. These resistances must be less than 10  $\Omega$  so that the RS-485 signal is not overly attenuated.

## 13.2 Layout Example

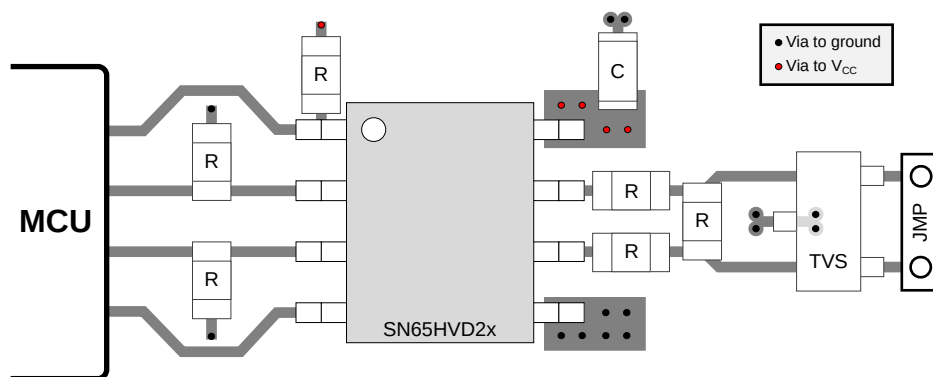


Figure 32. SN65HVD2x Layout Example

## 14 Device and Documentation Support

### 14.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

**Table 6. Related Links**

| PARTS     | PRODUCT FOLDER             | SAMPLE & BUY               | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| SN65HVD20 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| SN65HVD21 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| SN65HVD22 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| SN65HVD23 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| SN65HVD24 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

### 14.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 14.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

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### 14.4 Trademarks

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### 14.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 14.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 15 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| SN65HVD20D       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP20                    | <a href="#">Samples</a> |
| SN65HVD20DG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP20                    | <a href="#">Samples</a> |
| SN65HVD20DR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP20                    | <a href="#">Samples</a> |
| SN65HVD20P       | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD20                 | <a href="#">Samples</a> |
| SN65HVD21D       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP21                    | <a href="#">Samples</a> |
| SN65HVD21DG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP21                    | <a href="#">Samples</a> |
| SN65HVD21DR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP21                    | <a href="#">Samples</a> |
| SN65HVD21DRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP21                    | <a href="#">Samples</a> |
| SN65HVD21P       | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD21                 | <a href="#">Samples</a> |
| SN65HVD21PE4     | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD21                 | <a href="#">Samples</a> |
| SN65HVD22D       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP22                    | <a href="#">Samples</a> |
| SN65HVD22DG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP22                    | <a href="#">Samples</a> |
| SN65HVD22DR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP22                    | <a href="#">Samples</a> |
| SN65HVD22DRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP22                    | <a href="#">Samples</a> |
| SN65HVD22P       | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD22                 | <a href="#">Samples</a> |
| SN65HVD22PE4     | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD22                 | <a href="#">Samples</a> |
| SN65HVD23D       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP23                    | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| SN65HVD23DG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP23                    | <a href="#">Samples</a> |
| SN65HVD23DR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP23                    | <a href="#">Samples</a> |
| SN65HVD23DRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP23                    | <a href="#">Samples</a> |
| SN65HVD23P       | ACTIVE        | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD23                 | <a href="#">Samples</a> |
| SN65HVD24D       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP24                    | <a href="#">Samples</a> |
| SN65HVD24DG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP24                    | <a href="#">Samples</a> |
| SN65HVD24DR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP24                    | <a href="#">Samples</a> |
| SN65HVD24DRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 85    | VP24                    | <a href="#">Samples</a> |
| SN65HVD24P       | LIFEBUY       | PDIP         | P                  | 8    | 50             | Pb-Free<br>(RoHS)          | CU NIPDAU               | N / A for Pkg Type   | -40 to 85    | 65HVD24                 |                         |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

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**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

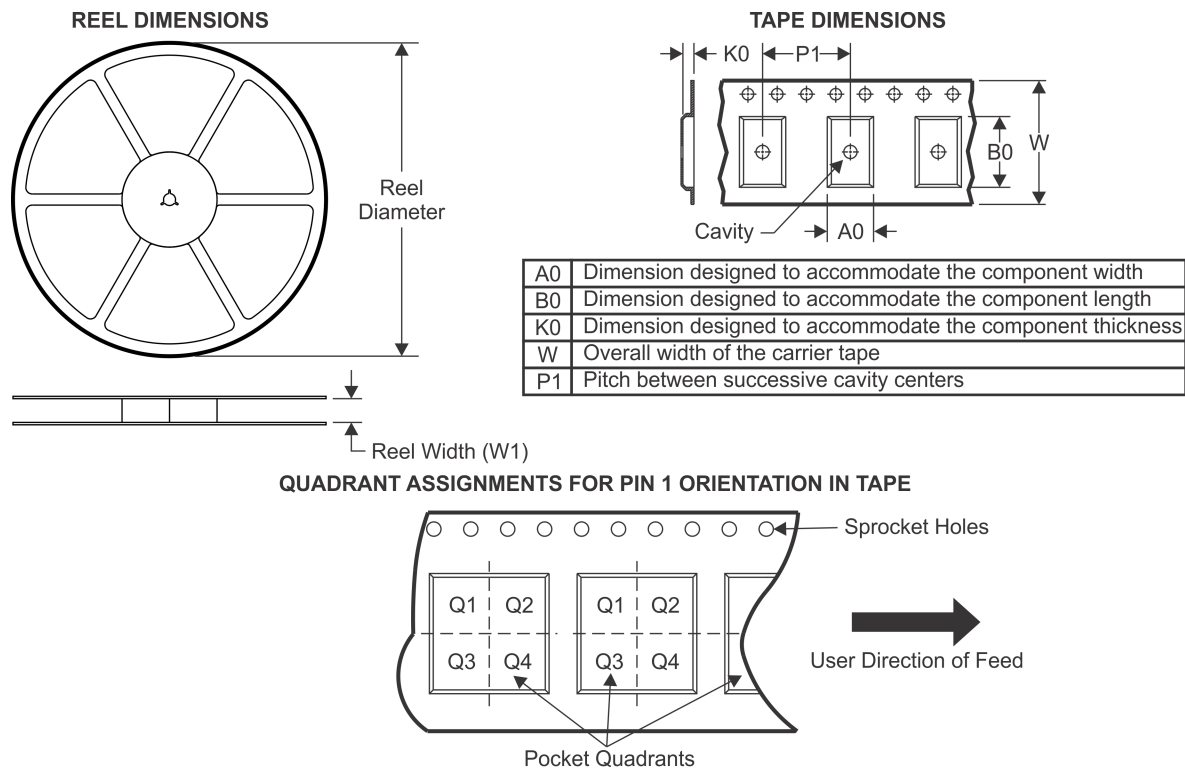
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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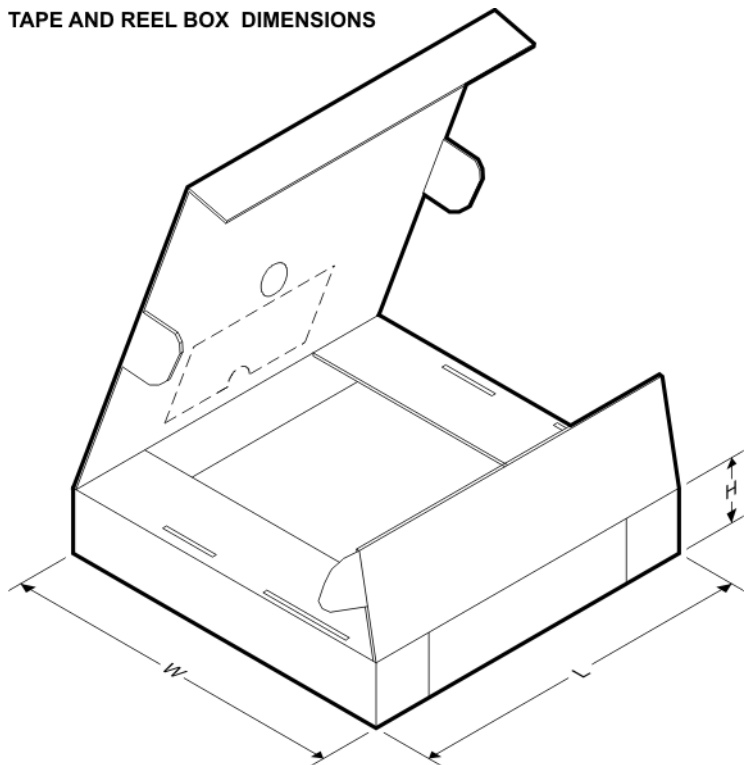
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**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| SN65HVD20DR | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| SN65HVD21DR | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| SN65HVD22DR | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| SN65HVD23DR | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| SN65HVD24DR | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS

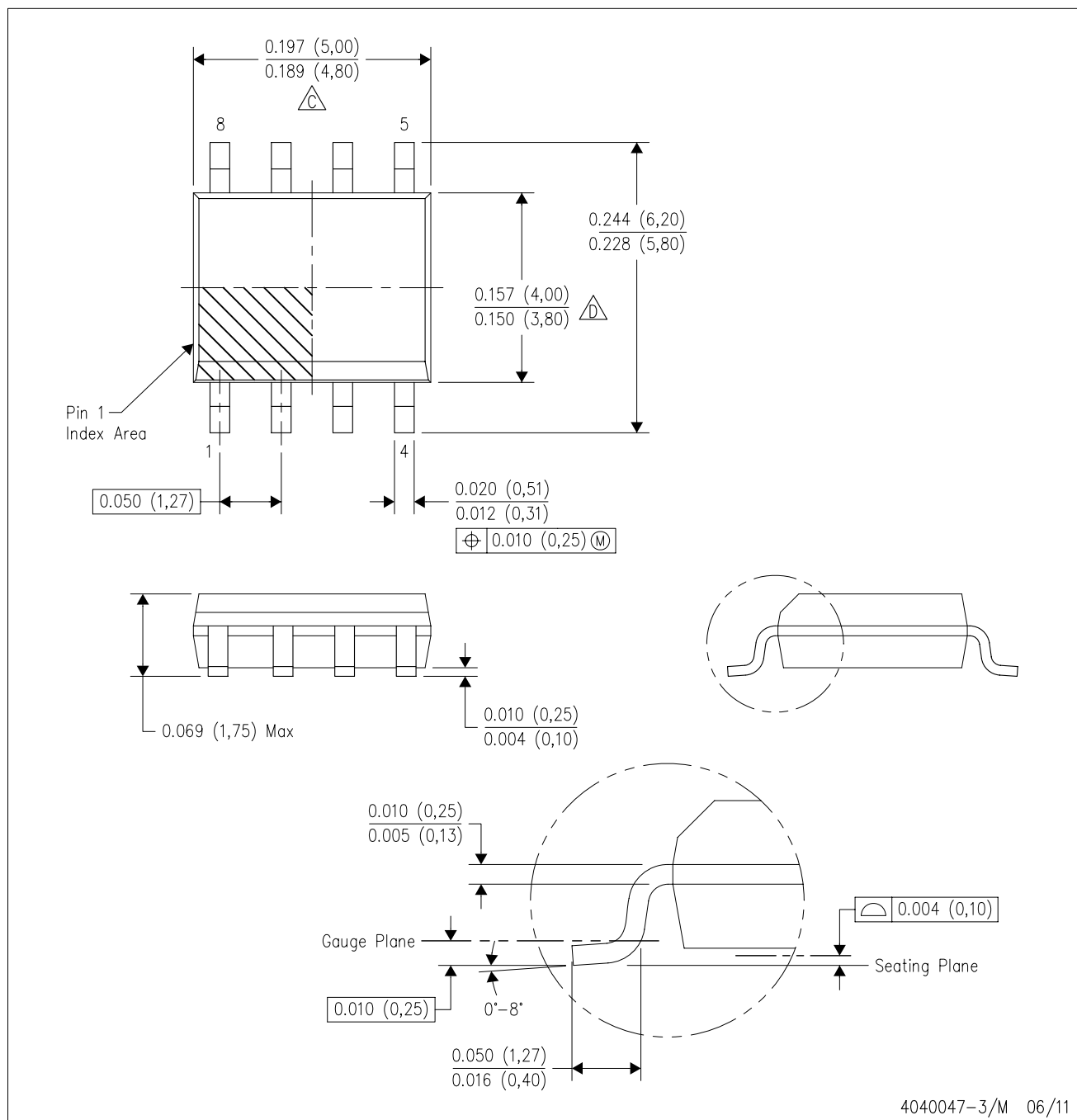


\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| SN65HVD20DR | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| SN65HVD21DR | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| SN65HVD22DR | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| SN65HVD23DR | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| SN65HVD24DR | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |

D (R-PDSO-G8)

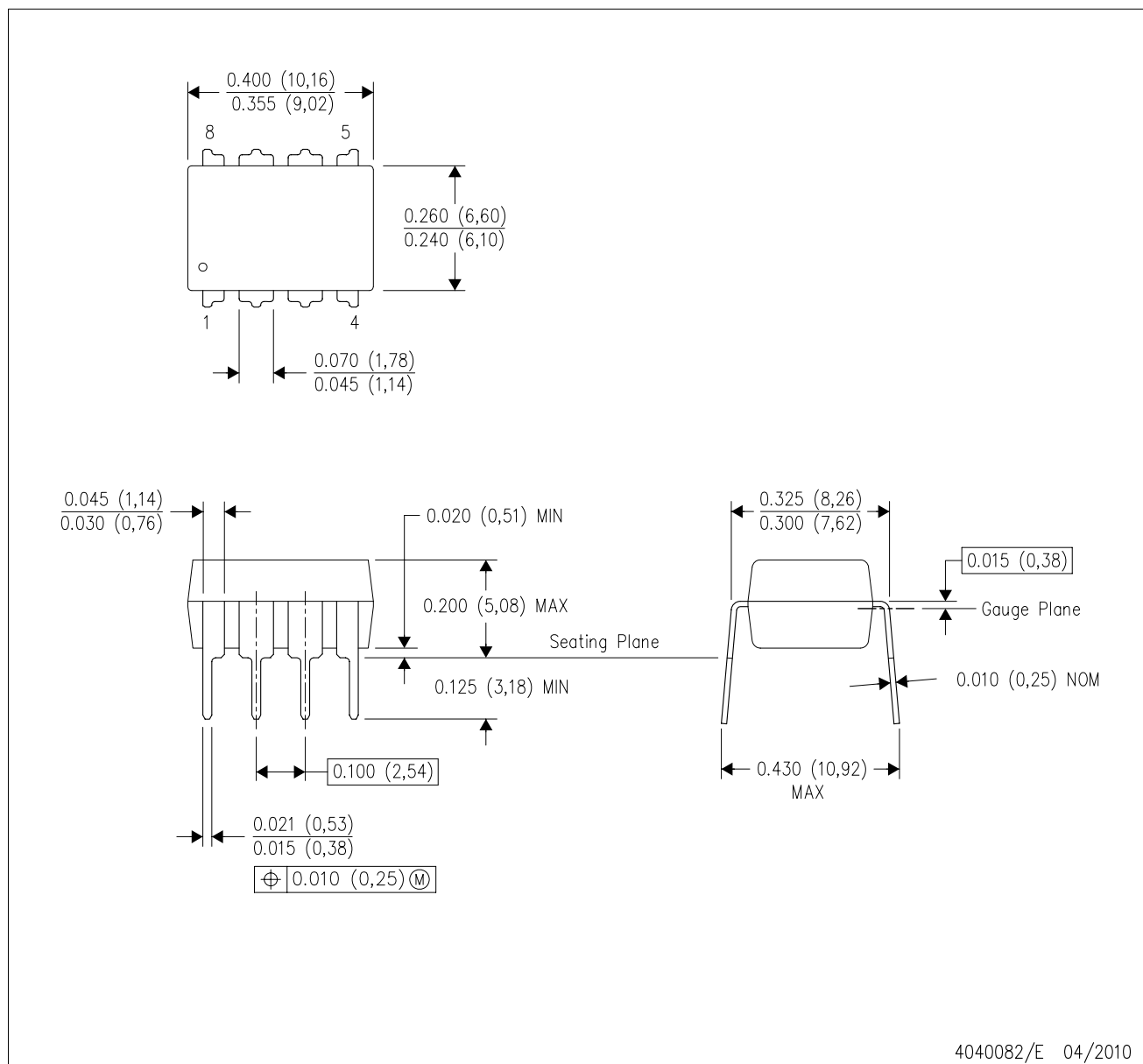
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AA.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

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